The 2nd International Conf. on Water Resources & Arid Environment (2006)

Water Import and Transfer versus Desalination in Arid Regions: GCC Countries Case Study

Mohamed A. Dawoud[1] and Walid Abderrahman[2]

[1]*Water Res. Dept., Terrestrial Environmental Res. Center, Environment Agency, Abu Dhabi, UAE*
[2]*Water Res. Manag., Res. Institute, King Fahd Univ., for Petroleum and Minerals, Dhahran, Saudi Arabia*

Abstract

The scarcity of water resources and the increasing gaps between demand and available supply in the Gulf Cooperation Council (GCC) countries is a major challenging issue facing the development sectors. GCC countries have extremely dry climate with rare rainfall, high evaporation rates and limited non-renewable groundwater resources. At present all GCC countries except Oman fell in the critical water scarcity category which is about 500 m3 of renewable water/cap/year. In addition, governmental policies with regard to increasing the level of food self-sufficiency through subsidies and other incentives, have contributed to a major expansion in and unrestricted use of non-renewable groundwater resources. This coupled with a lack of defined policies and strategies geared toward optimizing and managing the scarce water supplies within the GCC region, have contributed to wasteful and uneconomic practices, as well as to the inefficient mining of non-renewable supplies. To meet the present and future water demands of the region the available options are limited to either long distance water transfer and import from other countries or investing in large scale seawater desalination production. In this paper the economical, technical, sustainability and the political criteria affecting the two alternatives have been evaluated. Economic analysis revealed that the cost of long distance water transfer can escalate to more than 0.83 US Dollars per cubic meter. When sustainability considerations are taken into account this figure may reach up to 2.35 US Dollars per cubic meter. While these figures were competitive with the cost of seawater desalination twenty years ago, the situation has been recently shifted in favor of seawater desalination which dropped from 5.5 US Dollars in 1979 to less than 0.55 US Dollars in 1999 using the RO technology. It is concluded that sustainable development of GCC countries will depend in the future on large scale desalination. Presently planned water transfer projects should be substituted by this fast growing technology as the best option. Expanding desalination capacity in the next 20 years will

be possible by building new plants or upgrading the existing facilities in GCC countries. This process, however, will require high economic investment.
Keywords: Water transfer, Desalination, Water demand, Water management, Cost analysis, Decision making.

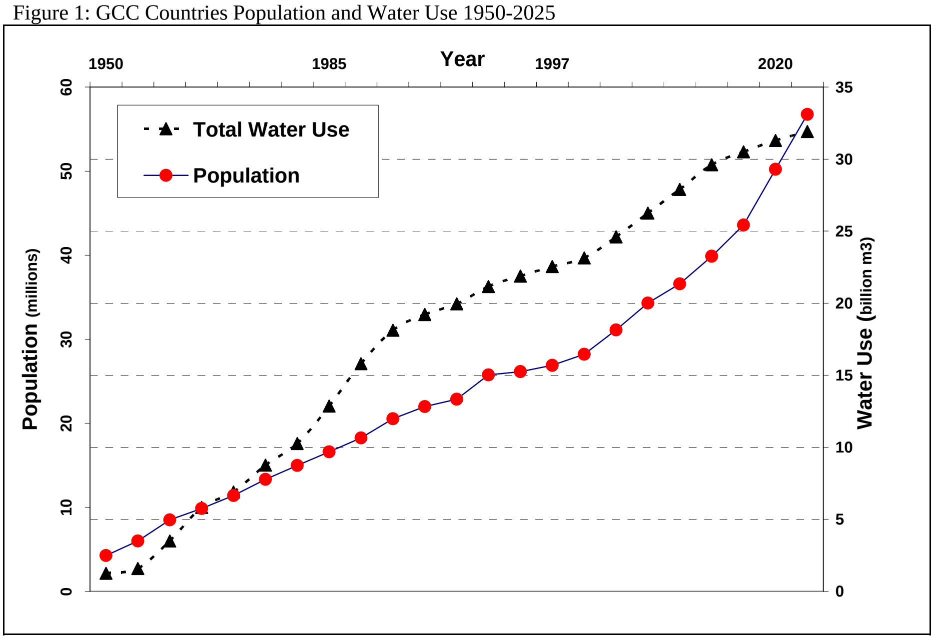
Introduction

Water is essential for all forms of life and is a fundamental resource for human survival and socio-economic development besides for maintaining healthy ecosystems. Consequent to rising water demand, it is rapidly becoming a scarce resource for most of countries in the arid and semi-arid regions which requires new methods and innovative approaches for water conservation and judicious use. The dependence of rapidly growing development sectors in arid and semi-arid regions on the water holds a special place in the water scarcity and management debate (FAO, 1999). The increased pressure on water resources due to (1) population growth- demanding not only more water for food, but also inducing changes in hydrological cycle, (2) changes in life style and urbanization and (3) climate change, lead to water scarcity and increased competition for water between agriculture, industries and the rapid growing cities. Water tables are now falling in most of the arid and semi-arid region of the world.

GCC countries are a part of water competitive world and water deficit grows larger with each year, making it potentially more difficult to manage. Conventionally available water supplies on renewable basis in these countries are simply insufficient to meet the increasing water demands of the present modes of economic activities and resource exploitation. The six counties that comprise the GCC occupy a total land area of 2.7 million km^2 and their combined population is currently over 30 million and is expected to top 40 million by 2010. Over the last quarter of a century there has been a three and four-fold increase in population and total water use respectively as shown in Figure 1. At the start of the 3rd Millennium, all GCC countries, except Oman ($583 m^3$/cap/yr) fell in the critical water scarcity category; < 500 m^3 renewable water/cap/yr. Total water demands are expected to increase 36% over the next decade. Today 91% of the combined total water demand is abstracted from groundwater, 7.2% by desalination of ground and sea-water and the remainder from treated effluent and surface water. On average, agriculture accounts for 85% of all water used and the current deficit of water resources is estimated at 15 Bm^3 (Al Zubari, 2002); a detailed summary of Water Resources of GCC states is not discussed here but can be found elsewhere (Al Rashed and Sherif, 2000). All GCC countries are becoming increasingly dependent on the non-sustainable mining of local groundwater aquifers that are presently threatened by pollution and depletion. This makes it essential to start giving a serious consideration for non-conventional water resources for their full potential development. The search is on for alternative water supplies that are economically viable, environmentally sound and socially equitable (Dawoud, 2005).

Many researches indicate that, to meet the present and future water demands of the region the available options are limited to either long distance water imports and transfers from the neighboring countries or to investing in large scale seawater desalination technology (Brook et al. 2006, Dawoud 2005, and World Bank 2006). In this paper the proposed projects for water import and transfer will be analyzed and discussed.

Figure 1: GCC Countries Population and Water Use 1950-2025



Present Status of Water Resources

1. Groundwater Resources

Many groundwater aquifers in GCC countries are being mined in an uncontrolled and unplanned manner, either because it has not been possible to regulate the access to these aquifers and/or they are non renewable. Unplanned groundwater mining erodes the economic and social sustainability of the communities that depend on the depleting storage. Whether the groundwater mining is inadvertent or planned, there is a need for guidelines to make the concerned communities better prepared economically and socially to cope with the increasing water stresses as the storage is depleted.

Table 1 shows that the annual groundwater recharge in GCC countries is about 4875 MCM. Groundwater abstractions during 2002 exceeded the annual replenishment of about 14697 MCM which is about 75%. Thus, considerable groundwater mining takes place, mainly for irrigation use. Because of the overexploitation, the actual contribution of groundwater to the total use in the region is more than 75%. At country level, groundwater abstractions are currently the main source of water in the GCC countries. Overall, the contribution of groundwater abstractions to total demand ranges from less than 68% (in Kuwait) to more than 90% (in Bahrain).

The groundwater resources quality has been threatened by increasing levels of depletion and pollution and the salinity in many local areas increased from less than 500 to more than 10,000 ppm or even more. Using such poor quality water has negative environmental impacts.

Table 1. Renewable Water and Groundwater Use in the GCC Countries (year 2002).

Country	Population (x1000)	Renewable Resources (MCM)			Groundwater Use (MCM)	GW significance, in terms of:	
		Surface water	Groundwater	Total		% of renewable GW to total renewable water	% GW use to total demand (year 2000)
Bahrain	677	0.2	100	100.2	258	99.80	91.49
Kuwait	2165	0.1	160	160.1	405	99.94	68.64
Oman	2518	918	550	1,468	1644	37.47	89.01
Qatar	599	1.4	85	86.4	185	98.38	53.31
Saudi Arabia	21930	2,230	3,850	6,080	14430	63.32	81.23
UAE	2411	185	300	315	2650	41.27	78.50
Total	30300	3334.7	4875	8209.7	19572	59.43	75.34

2. Desalinated Water Production

In order to meet both the qualitative and quantitative requirements for drinking water standards, domestic water supplies in the GCC countries rely mainly on desalination plants produced water, which are used either directly or blended with groundwater. Rural areas have proposed from a number of desalination plants where water is transported over long distances from coastal areas to interior regions. Desalination of seawater and brackish groundwater will continue to be a viable water supply augmentation option for large number of urban centers in GCC countries. Considering recent cost-cutting innovations in the desalination process, this alternative may prove to be relatively inexpensive supply option in comparison to the development of conventional sources located in remote locations. The availability of desalinated water at relatively low cost may also be an attractive means of meeting industrial water demand because industries have been willing to pay for water at rates higher than domestic and agricultural use rates. In 1990 the GCC countries together produced 1557 MCM annually with a daily rate of about 4.26 MCM or per capita 30 liters a day at the national average (Alghariani, 1999). In 1990 the total annual desalinated water capacity was about 2012 MCM with a total produced water of about 1548 MCM as shown in Table 2 (Brown and Root, 1990).

In order to meet domestic water demands, which is a function of population and urbanization growth, the GCC countries are going ahead with desalination plants construction, despite their relatively enormous costs, which range between 1-1.5 US$/m3. The total annual desalination capacity of the GCC countries at present (2002) is about 2817 MCM. Many types of desalination processes are used such as MSF, RO, PV, and others. MSF are sued seawater and dominates the desalination market by more than 74%. RO is sued mainly for brackish groundwater treatment. A growing trend is toward the application of RO in the desalting of sweater due to the advanced development in membrane technology. Limited numbers of MED plants are used (Dawoud 2005).

Table 2. Past and Present Desalination Schemes in GCC Countries.

Country	1990			2002		
	Desalination Production (MCM)	Domestic Demand (MCM)	Desalination to Demand ratio (%)	Desalination Production (MCM)	Domestic Demand (MCM)	Desalination to Demand ratio (%)
Bahrain	56	103	54	122.7	135	91
Kuwait	240	303	79	440	590	75
Oman	32	86	37	103	158	65
Qatar	83	85	98	194.31	201	97
Saudi Arabia	795	1700	47	1022	2450	42
UAE	342	540	63	811	835	97
Total	1548	2817		2693.01	4369	

3. Reuse of Treated Wastewater

Introduced in the early eighties in most of the GCC countries, treated wastewater represents one of the most important alternatives that can be used to meet some of the present water requirements and to lessen the long term supply vs. demand imbalance faced by these countries. Due to completion of sewage water treatment facilities and urban sewage networks expansion in most of the GCC large cities, relatively large volumes of treated wastewater have become available, and because of environmental considerations, have been treated completely or partially regardless of their utilization. Some of the issues encountered in wastewater treatment and usage in some GCC countries are the low rate of wastewater treatment due to the limited sewage network coverage (around 60% in the main metropolitan areas) as a result of the rapid rate of population growth; treatment capacity constraints in the major urban centers that require high investment costs; and the high proportion of wastewater that is treated but not used. Table 3 displays the current treated volumes of wastewater and the reused volumes in the GCC Countries.

Table 3. Treated Wastewater Production and Use in GCC Countries (year 2002)

Country	Treated Wastewater Production (MCM)	Treated Wastewater Use (MCM)	Used to Production ratio (%)
Bahrain	24	24	100
Kuwait	258	250	97
Oman	15	11	73
Qatar	44	44	100
Saudi Arabia	475	225	47
UAE	265	215	81
Total	1081	769	

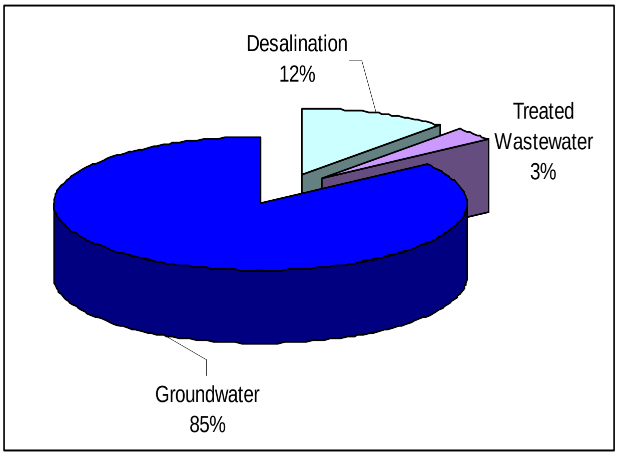
At present, all the six countries are operating modern treatment facilities with tertiary and advanced treatment capabilities. The total designed treatment capacity of the major facilities is more than 1,600 Mm3/y, with a present total treated wastewater volume of more than 1081 Mm3/y. However, the recycled volumes of these waters are about 769 Mm3/y, which is about 71% of the total treated wastewater. Recycling is used mainly in urban uses (irrigating gardens, roads ornamentals, etc.), fodder crops irrigation, and highways landscaping. Figure 2 shows the percentage of water use by source.

Water Demand

Population growth and rapid development in the agriculture and industrial sectors in GCC countries are major issues affecting all sustainable socio-economic development (Ismail, 1995). The estimated population in 2002 was 30.3 million with an average growth rate of 3.73 per cent (UNSPD, 2002). Population projections for GCC countries over the period 1995-2025 are given in Table 4.

The total renewable water in the GCC countries in 2002 amounted to 8209.7 MCM. The high population growth rate in the region exceeds by far the rate of water resource development. Consequently, the annual per capita share of water resources is decreasing, and at an increasing rate. Five countries in the region have a per capita water use of under 500 cubic meters a year, half the benchmark of 1 000 cubic meters a year which indicates chronic water scarcity. The national economy of most countries depends on oil and oil-related industries, commerce, light industries, and agriculture, in this descending order. Due to the fast increase in population and urbanization, domestic water and industry needs are escalating at rates with which available water resources cannot keep pace. Furthermore, the adopted policy of food self-sufficiency imposes continual constraints on the allocation of water resources, which would otherwise reduce the share for agriculture in favor of increased domestic and industrial demand. Currently the agricultural sector takes 85 % of available water resources followed by domestic water use, 14 % and 4 % for commercial and industrial use as shown in Table 5 (WRI/UNEP/UNDP/WB, 2002).

Figure 2. Percentage of water use by source (Year 2002)



The water stress experienced by the GCC countries in 2002 is expressed in Table 6 as the percentage of available water resources actually used. The index reaches values of over 100 per cent in five of the six countries and critical values in the remaining one. This indicates that these countries have already exhausted their renewable water resources and are now exploiting non-renewable reserves. The overall value of the water stress index is 252 per cent. From this deteriorating water stress index, it is clear that current water resources cannot satisfy future water demand unless positive steps are taken soon to rationalize water demand management, increase and augment supply, and impose realistic controls on use. The negative impacts include fast depletion of aquifer reserves, possible conflicts arising from differential use of aquifers shared between states, deteriorating water quality and salinisation of agricultural lands.

Table 4. Past and Projected population in GCC countries

Country	Projected Population (x1000)							Percentage Ration (2025/1995)
	1995	2000	2005	2010	2015	2020	2025	
Bahrain	557	618	671	717	766	897	1049	188
Kuwait	1691	1966	2192	2390	2576	3076	3673	217
Oman	2027	2717	3302	3986	4752	7002	10316	509
Qatar	548	599	648	693	734	842	967	176
Saudi Arabia	18255	21661	25255	29222	33483	45580	62048	340
UAE	2210	2410	2660	2869	3049	3526	4078	185
Total	25288	29597	34728	39877	45360	60828	81570	323

Table 5. Past and projected water demand in GCC countries (million cubic meters)

Country	1995			2000			2025		
	Domestic	Agriculture	Industrial	Domestic	Agriculture	Industrial	Domestic	Agriculture	Industrial
Bahrain	86	120	17	117	124	26	169	271	169
Kuwait	295	80	8	375	110	105	1100	140	160
Oman	75	1150	5	151	1270	85	630	1500	350
Qatar	76	109	9	190	185	15	230	205	50
Saudi Arabia	1508	14600	192	2350	15000	415	6450	16300	1450
UAE	513	950	27	750	1400	30	1100	2050	50
Total	2553	17009	258	3833	18089	676	9679	20466	2229

Furthermore, existing wastewater treatment facilities can cope with only 75 % of urban and industrial waste. Pollution from inappropriate disposal of untreated wastewater will create health hazards through the contamination of shallow groundwater aquifers. These issues are all aggravated by a general weakness among the institutions dealing with water affairs. This is due to inadequate technical capabilities and unsatisfactory coordination between concerned water authorities (UNEP and ACSAD, 2000).

The Available Mitigation Measures and Options

Escalating water demands during the past 20 years in the GCC countries led to severe pumping and overdraft of the local groundwater aquifers with limited extent and limited annual recharge. These aquifers have been exposed in several locations to unacceptable levels of piezometric declines and seawater intrusions with disastrous environmental and socioeconomic impacts. However, since there is no available surface water supplies to remedy the resulting deteriorating situation, the only available options are limited to the followings:

(1) Expanding groundwater exploitation in newly developed, previously untapped, aquifers;
(2) Investing in large scale seawater desalination technology; and
(3) Importing and transferring water from neighboring countries

Table 6. Water Stress Index in GCC countries (2002)

Country	Population (x1000)	Renewable Water Resources (MCM)	Exploited Water Resources (MCM)	Per capita Water Resources (m3/y)	Water Stress Index (%)
Bahrain	677	100.2	287	164	258
Kuwait	2165	160.1	538	158	156
Oman	2518	1,468	1841	980	74
Qatar	599	86.4	439	466	157
Saudi Arabia	21930	6,080	21155	313	307
UAE	2444	315	3112	316	408
Total	30300	8209.7	25872	358	252

The first option is considered as short term mitigation measure and can be considered as long term due to the limit extent of these aquifers and their potential is very limited. Expanding groundwater exploitation will lead to sever environmental, health and economic problems. The cost of groundwater pumping will increased dramatically due to the drop in water table and the effect of increasing groundwater salinity of the wells material and pumps shortening their life time and increasing the rehabilitation and maintenance costs. Therefore the other two options are discussed in terms of technical, economical, environmental and political issues in this paper.

1. Large Scale Seawater Desalination

Desalination has become a major water supply component in the GCC countries as a result of groundwater salinity problems and the remote locations of potential groundwater sources that exist far from major urban areas. The GCC countries, by necessity, have become the world leader in sea and brackish water desalination. However, the cost of water production remains high, ranging from 0.5 to 1.5 US$ per cubic meter, which is substantially higher than what the public is charged. Desalination technology in the region has been clouded with several misconceptions and lack of understanding its multifarious aspects. Top level decision makers usually associate desalination with international companies of imperialist tendencies that monopolize this technology to extract the highest possible price for its products. These misconceptions should be immediately corrected since all available facts and information, as will be demonstrated later, clearly indicate that desalinated water is no longer so expensive as it has been thought and desalination technology is not monopolistic.

1.1. Projection of Future Potential in Desalination Growth

The current per capita desalination capacity Q_{2003} m3/cap/day can be calculated from seawater and brackish water desalination for municipal use and attributed to the current urban population in each country according to Equation (1).

$$Q_{2003} = \frac{\left(Q_{sw}.Y_{sw} + Q_{bw}.Y_{bw}\right)}{N_{2003}.U} \qquad \text{(Eq. 1)}$$

where Q_{sw} and Q_{bw} are seawater and brackish water desalination capacity (m3/d), Y_{sw} and Y_{bw} are the share of municipal water from sea and brackish water desalination, respectively, N2003 is the current population in each country, and U represents the share of the population in urban centers [Bremere et al., 2001].

To estimate the potential growth in the municipal water desalination industry, the following assumptions were made:

- Growth in desalination is determined based on the rate of population increase in the GCC countries in the next 25 years.
- Only the population in urban areas will use desalination to augment their current water supply.
- By year 2025, water for municipal (domestic) supply will be met completely from desalinated water and no surface water or withdrawals of groundwater will be used for municipal use in any of GCC countries.

The potential growth in desalination in each of GCC countries was calculated by the difference between the present desalination capacity at year 2003 and the required demand for domestic water supply by the year 2025 and can be expressed by Equation (2).

$$\Delta Q_{2025} = Q_{2025} - Q_{2003} = \left(N_{2025}.U.WW_{2025}\right) - \left[\frac{Q_{sw}.Y_{sw} + Q_{bw}.Y_{bw}}{N_{2003}.U}\right] \qquad \text{(Eq. 2)}$$

where N_{2025} is the projected population of each country by 2025 and WW_{2025} is the per capita municipal domestic water use by 2025 in (m^3/cap/day).

The development of desalination for municipal use between 1990 and 2002, and the projected growth in desalination capacity in the GCC Countries for the next 20 years is summarized in Table 7. The driving force determining the need for the desalination development is assumed to be the increase in population. However, due to limited potential of brackish groundwater, there will also be a need for using desalinated water in agriculture, parks, gardens and forests.. This will most probably increase the desalination production by year 2025 if there is no reform to the agriculture policies in these countries to stop the expansion in, or even reduce the area under irrigation.

Table 7. Estimated future development in the desalination market.

Country	1990		2002		2025	
	Population (x1000)	Desalination Production (MCM)	Population (x1000)	Desalination Production (MCM)	Population (x1000)	Estimated Desalination Production (MCM)
Bahrain	404	56	677	122.7	1483	161.96
Kuwait	1292	240	2165	589.1	4744	749.34
Oman	1503	32	2518	67.932	5517	114.13
Qatar	358	83	599	194.317	1312	252.61
Saudi Arabia	13090	795	21930	1063.28	48051	1690.62
UAE	1459	342	2444	812.61	5355	1357.06
Total	18086	1548	30300	2849.94	66391	4325.71

1.2. Desalination Costs

Cost is a primary factor in selecting a particular desalination technique for fresh water production. Desalination costs have decreased markedly in the last few decades as shown in Figure 3. The recent studies and analysis indicate that the cubic meter cost of desalination for seawater based on the Gulf seawater quality having a TDS of 45,000 ppm in GCC countries ranges from 0.86 to 1.06 US dollars depending on the ratio of recovery (Madwar, and Tarazi, 2002). Table 8 summarizes the cost elements included in a seawater desalination plant. However the cost for desalinating the brackish groundwater will be less than these figures using RO technology. The costs of desalinating brackish groundwater in GCC countries using RO have reduced from 2.5 to 0.38 US dollars/m³ and this will continue decreasing in line with improved membrane plant performance (e.g. decreased water pressure requirements, increased injection of salt, longer operating lifetimes, improved energy recovery, and plant automation) and improved economics associated with large scale production of membranes. Also it is very important to mention that in any evaluation of desalination costs it is important to consider the hidden costs associated with using water with a high salt or mineral content.

1.3. Effect of Energy Cost on Desalination

Energy costs represent a remarkable contribution to the cost of produced water from the different desalination systems, with an average that varies between 20 and 30 % and up to 50 % for MSF. As a result, energy costs could become prohibitive for the MSF and it would far exceed the membrane replacement unit cost. In this case, the economic advantages of the RO system would be very significant. Figure 4 illustrates the effect of fuel prices on the cost of desalinated water using MSF and RO systems. The figure shows the slight impact of energy prices on RO systems and the remarkable impact on MSF systems and that this would also vary with the capacity of these systems as shown by the range of prices (Madwar and Tarazi, 2002).

Figure 3. Reduction in desalination costs in last 40 years.

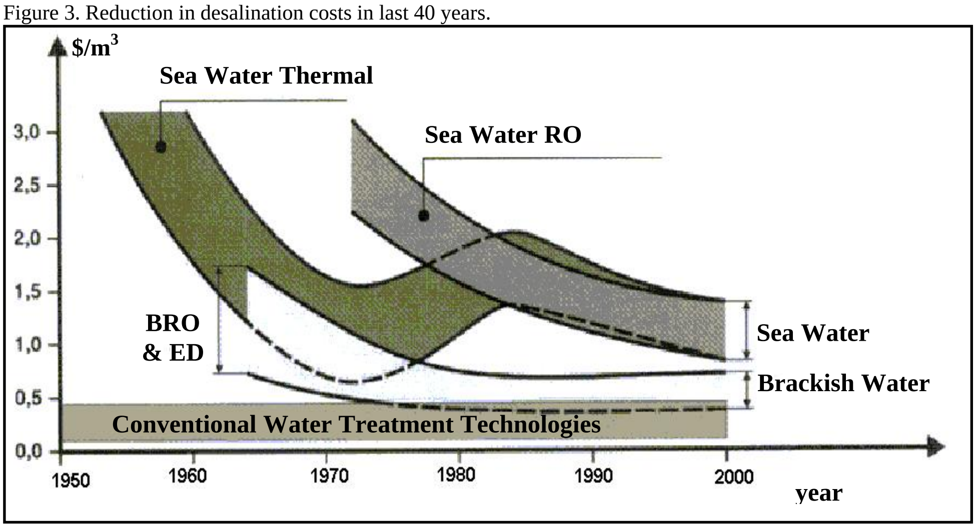


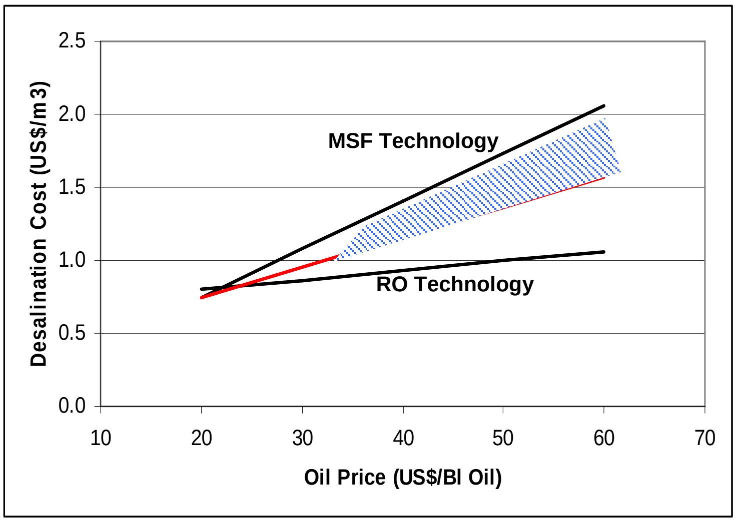
Table 8. Total capital and running summary costs for seawater desalination.

Cost Item	Cost in US dollars/m³ (35% recovery)	Cost in US dollars/m³ (45% recovery)
Capital costs	0.35	0.29
Operation staff	0.048	0.048
Chemicals	0.10	0.08
Energy	0.43	0.33
Maintenance	0.138	0.11
Total (US dollars)	1.06	0.86

1.4. Approaches for Desalination Cost Reduction

One way to reduce the cost of desalinated water is to improve the desalination technology and increase the performance ratio (the ratio of fresh water to the amount of energy consumed). There are a wide variety of water production costs, depending on plant size and energy prices. Usually, costs decrease with increased plant capacity (Faraj, 2000). Costs reported by the GCC countries are usually less than for countries in the rest of the world because of subsidized energy charges. For example, the cost of producing 1 m3 of water in Saudi Arabia ranges from $0.48 to $2.20; from $1 to $1.45 in the United Arab Emirates; $1.14 to $1.64 in Qatar and $0.56 in Bahrain. Over the past 15 years, major advances have been made in certain desalination technologies, which have resulted in notable cost reduction (El-Nashar, 2001). Several approaches were proposed by different experts in the field for reducing the cost of desalinated water from conventional desalination plants.

Figure 4. Effect of energy cost on the cost of desalinated water using MSF and RO.



2. Water Import and Transfer

Due to the sever shortage of renewable water resources in the GCC countries and the cost of using non-conventional resources various projects to import and transfer water from neighboring countries were suggested.

2.1. Turkish Peace Water Pipelines

The concept of exporting Turkish water to promote regional peace and economic development in the Middle East has been a constant in Turkish foreign policy since the late President Turgut Özal in 1986 proposed an extensive "Peace Water Pipeline" This was a $21 billion project to bring vast quantities of water from the Seyhan and Ceyhan Rivers via two pipelines with a length of about 6500 km to supply the major cities in Syria, Jordan, and the GCC countries. The pipelines could convey 10 million cubic meters of water every day, which was estimated as sufficient to meet the needs of 15 million persons. Table 9 shows the water share of each country from the proposed two pipe lines (Robins, 1996).

2.2. The Nile Option

In theory, another potential source of water for GCC countries is the Nile River. Some years back, it has been proposed an arrangement for importing and transfer water from Nile to Saudi Arabia and then to the other GCC countries either from Sudan or Egypt passing through the Red Sea. The Nile River runs through ten riparian countries in northern and eastern Africa: Burundi, Egypt, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda, and Zaire. It is expected that due to Egypt's and Sudan's high population growth, increased irrigation activity, and worsening water quality, the two countries will not have sufficient water to meet their demand by the turn of the century. The primary agreement which dictates allocations on the Nile is the 1959 Nile Waters Agreement between Egypt and Sudan. This agreement basically allocates 66 percent of the flow to Egypt, 22 percent to Sudan, 10 percent to losses (Smith and Al-Rahway, 1990). So, practically Egypt and Sudan would not be able to provide any Nile water to GCC countries. To do so would arouse fierce opposition and would undermine the water sharing agreements that Egypt and Sudan has so painstakingly negotiated with the other nine upper riparian states (Wahby, 2003).

Table 9. Water share of each country from Turkish peace water pipelines.

Western Pipeline		Eastern Pipeline	
Country	Water Share (m^3/min)	Country	Water Share (m^3/min)
Turkey	300	Kuwait	600
Syria	1100	Saudi Arabia	400
Jordan	600	Bahrain	200
Saudi Arabia	1500	Qatar	100
		UAE	600
		Oman	200

2.3. Importing water from Karkheh Dam to Kuwait

In 2003, an agreement was signed between Iran and Kuwait to export water from Karkheh Dam to Kuwait. The plan on the transfer of Iran's water to Kuwait was brought to public attention in year 2000 and a consortium made up of British, Kuwaiti and Iranian companies took responsibility for drawing the plan and the executive operations.

According to the proposed plan, Iran's water will be transferred to Kuwait via a 540 km long pipeline. A 330km pipeline is to carry the fresh water to the farthest point on the bank of the Arvand River, located in Abadan, the capital of the province, and will be extended about 210km toward the coast of Kuwait under the sea. This pipeline will supply Kuwait with 900,000 cubic meters of fresh water per day (10 cubic meters per second) from Karkheh Dam, which is located in southern oil rich province of Khuzestan, through the projected pipeline for 30 years. Based on the preliminary estimations, the project will cost 1.5 billion dollars and the revenue gained by Iran will apparently be spent on the construction of new dams and water installations in Iran (Dawoud, 2006).

2.4. Importing water from India

One of the alternative is to import and transfer water from India through the Omani Gulf to the northern Emirates in UAE. Then, a big dam to be constructed to reserve and pump the water into two pipelines to the other GCC countries. The eastern pipeline will divert the water to Oman while the western one will divert the water to Bahrain, Qatar and Kuwait. The preliminary studies indicated that the construction of this project is not fesable due to the complicated physical setting th epipieline passing through.

2.5. Importing water from Pakistan

Also it was proposed to import and transfer water from India through the Omani Gulf to the northern Emirates in UAE. Then, the water can be pumped into two pipelines to the other GCC countries. The eastern pipeline will divert the water to Oman while the western one will divert the water to Bahrain, Qatar, Saudi Arabia and

Kuwait. The preliminary studies indicated that the construction of this project is not feasible due to the complicated physical setting the pipeline passing through.

Sustainability and Cost Comparison

The only available example of mass water transfers that has been implemented in our arid region is the Libyan Great Man-made River project. After its completion the project will transfer and redistribute a total of more than 2 billion cubic meters per year. Whenever large-scale mass water transfers are considered, the financial resources available for investment in these projects and the expected cost of the transferred water are of prime concern. It is essential to compare the average unit cost of transferred water with the other potentially available alternate supplies. The economic analysis performed during project conception estimated the average unit cost of transferred water at about 0.25 US Dollars per cubic meter, which was highly competitive with other alternatives such as seawater desalination estimated at 2.5 – 3.0 US Dollars per cubic meter at that time. Actual economic studies performed after the completion of first stage (Brown and Root Overseas Ltd, 1990) revealed that the average unit cost of water to the user’s gate, with the cost of capital set at 7 percent interest, is 0.83 US Dollars per cubic meter at 1991 prices. It is generally believed that this figure has been dramatically exceeded for the remaining stages of the project since that time.

While there is a clear trend of increasing costs of transferred water with time, the cost of desalinated seawater has witnessed during the last two decades a dramatic revolutionary trend in the opposite direction. The average price of desalinated seawater is today only one-tenth of what it was twenty years ago. It dropped from 5.5 US Dollars per cubic meter in 1979 to less than 0.55 US Dollars in 1999, including interest, capital recovery and operation and management. A Tampa Bay seawater desalination plant in Florida, USA, was contracted in 1999 at a cost of 0.45 – 0.49 US Dollars per cubic meter in the first year of operation. However, the researchers always raise the issue of the vulnerability of desalination plants to pollution and emergency conditions.

In terms of cost comparison, it seems that mass water import and transfer projects in GCC countries at the moment have lost their economic advantages compared with the rapid development and cost reduction of new desalination technologies. When the questions related to sustainability considerations are raised, the advantages of the desalination option become even better. Beyond the relative costs of desalination versus the water imports from the neighboring countries, the GCC countries were weighing the political risks. However, the Kuwaiti experience also pointed out the vulnerability of desalination plants. When the retreating Iraqi forces set many Kuwaiti oilfields on fire, large quantities of oil spilled into the Arabian Gulf affecting the production of the desalination plants. Some political commentators in the GCC countries have questioned the sustainability of the giant multibillion dollar water import and transfer projects to GCC countries.

Conclusion and Recommendations

From the pervious analyses for the technical, economical, social, environmental, and political issues for the desalination and importing and transferring water to GCC countries, the following can be concluded:

- In the GCC countries, the need for more water is crucial to the goals of economic, social, industrial and environmental development. The available renewable water resources In the GCC countries have been fully utilized with extensive mining of the non-renewable groundwater resource, resulting in deterioration of the groundwater quality.
- It is clear that the water desalination industry is currently at an important stage, where the need for water availability and quality is increased in many places especially GCC countries. The production cost is declining due to healthy competition, while performance is improving along with production efficiency. No arguments are needed with respect to the quality of the water; the main struggle is still the cost of the production. It is clear, however, that the cost of water is steadily declining so that more people can afford desalination.
- Expanding desalination capacity in the next 20 years will be possible by building new plants or upgrading the existing facilities in GCC countries. This process, however, will require high economic investment.
- The driving force determining the need for desalination development in municipal domestic water supply is assumed to be the population growth from 18 millions in 1990 to 30 millions in 2002 and to the projected 66 millions by 2025. This will cause a continuous decline in the non-renewable groundwater resources.
- Depending on import and transfer water from neighboring countries in the main developing sectors at GCC countries has many social, environmental and political constrains.
- Economic analysis revealed that the cost of long distance water import and transfer can escalate to more than 0.83 US Dollars per cubic meter. When sustainability considerations are taken into account this figure may reach up to 2.35 US Dollars per cubic meter. While these figures were competitive with the cost of seawater desalination twenty years ago, the situation has been recently shifted in favor of seawater desalination which dropped from 5.5 US Dollars in 1979 to less than 0.55 US Dollars in 2000. It is concluded that sustainable development of GCC countries will depend in the future on large scale desalination as a strategic resources. Presently planned water transfer projects should be substituted by this fast growing technology as the best option.
- Some argue that the best long-term solution is to build a network of large-scale desalination plants. However, even if additional desalination plants were approved quickly, these would take several years to be constructed. During these years, the groundwater can be still used as short term solution.

- Though the construction of the water import and transfer projects is technically possible with high cost and environmental and political impacts and several serious problems remain to be solved. The imported water should not be used indirect in the development sector (e.g aquifer recharge).

References

Al Rashed, M.F and Sherif, M.M. 2000. Water Resources in the GCC Countries, Water Resources Management, Vol. (14), pp. 59-75.

Al Zubari, W.K., 2002. Alternative Water Policies for the GCC Countries, In UNEP Global Environmental Outlook (GEO) Project.

Alghariani, S.A., 1999. Managing Water Scarcity Through Man-made Rivers, Proceedings of the 27th IAHR Congress on Water for a Changing Global Community, August 10-15, San Francisco, California, USA.

Bremere, I., Kennedy, M., Stikker, A., and Schippers, J., 2001. How Water Scarcity will affect the growth in desalination market in the coming 25 years, Desalination, Vol. 1(38), pp.7-15.

Brook, M.C., Al Houqani, H., Al Mugrin, A., 2005. The current status and future requirements of water resources management in the Arabian Peninsula, In Policy Perspectives for Water and Ecosystem Management in the Arabian Peninsula, UNESCO.

Brown and Root (Overseas) Limited, 1990. Estimate of Cost of Water, Report No.(F1321A), The Management and Implementation Authority of the Great Man-made River Project, Benghazi, Libya.

Dawoud, M. A., 2005. The role of desalination in augmentation of water supply in GCC countries, Desalination Vol. (186), pp. 187-198.

Dawoud, M. A., 2006. Is the water import and transfer from neighboring countries in the the solution for water deficit in GCC countries (in Arabic), Arra Gulf views Journal, Gulf Research Center, Dubai, UAE, Vol. (22).

Dawoud, M. A., 2006. Towards sustainable and integrated water resources management in the GCC countries (in Arabic), Arra Gulf views Journal, Gulf Research Center, Dubai, UAE, Vol. (19).

El-Nashar, A. M., 2001. The Role of Desalination in the Water Management in Gulf Region, ADWEA publications, Abu Dhabi, UAE.

FAO, 1999. Irrigation in Asia in Figures, Water Reports No. 18. FAO Rome

Faraj, A. B., 2000. Desalination and Energy for Potable Water Supply in Arab Countries (in Arabic), Paper presented to the Seminar on Development of Energy Policies and their Relation to the Water Sector in the Arab World, Jordan.

Ismail, N., 1995. Strategic Projection for Planning and Management of Water Resources in GCC Countries (in Arabic), Attaawun, Vol. 10 (38), pp. 47-62

Madwar, K., and Tarazi, H., 2002. Desalination techniques for industrial wastewater reuse, Journal of Desalination, Vol. 52, pp. 325-332.

Robins, P., 1996. Avoiding the Question, in H. Barkey (ed.) Reluctant Neighbor: Turkey's Role in the Middle East, Washington DC: US Institute of Peace Press, pp. 179-203.

Smith, S.E. and H.M. Al-Rawahy. 1990. The Blue Nile: Potential for Conflict and Alternatives for Meeting Future Demands, Water International, Vol (15).

UNEP and ACSAD, 2000. Alternative Policy Study: Water Resource Management in West Asia, A part of the preparation for UNEP's Global Environment Outlook-2000 report.

UNSPD, 2002. World Urbanization Prospects: The 2002 Revision (Annex Tables). United Nations Secretariat, Population Division, New York, United States

Wahby, Hassan, 2004. Head of Institutional Reform Unit, Egyptian, Ministry of Water Resources and Irrigation, author’s interview, Alexandria, Egypt. December 13,

World Bank, 2006. A Water Sector Assessment Report on the Countries of the Cooperation Council of the Arab States of the Gulf, Technical Report No. : 32539-MNA.

WRI/UNEP/UNDP/WB. 2002. World Resources 2001-2002. RI/UNEP/UNDP/World Bank, Oxford University Press, New York, United States, and London, United Kingdom

نقل واستيراد المياه أم التحلية في المناطق الجافة؟: دول الخليج العربي نموذجاً

محمد عبد الحميد داود[1] و وليد عبد الرحمن[2]

[1]إدارة الموارد المائية – مركز بحوث البيئة البرية – هيئة البيئة – أبوظبي – الإمارات العربية المتحدة
[2] وحدة المياه – معهد البحوث – جامعة الملك فهد للبترول والمعادن – الظهران – السعودية

يعد شح الموارد المائية والفجوة بين المصادر المائية المتاحة والطلب على هذه الموارد تحديا كبيراً يواجه القطاعات التنموية المختلفة في دول الخليج العربي. وتقع دول الخليج في حزام المناطق الجافة وشديدة الجفاف مما يؤدي إلي قلة معدل الهطول المطري وانعدام وجود مصادر مائية سطحية دائمة الجريان وارتفاع معدلات البخر. وفي الوقت الحاضر تعاني جميع دول المنطقة من نقص حاد في مواردها المائية وتصنف عالمياً بوقوعها تحت خط الفقر المائي والذي يقدر بحوالي 500 متر مكعب من الموارد المائية المتجددة سنوياُ للفرد. وفي الوقت نفسه تشهد القطاعات التنموية تزايداً كبيراً وتتبنى بعض الحكومات سياسة دعم القطاع الزراعي بهدف تحقيق الأمن الغذائي والاكتفاء الذاتي وتقليل الاعتماد على الاستيراد للمواد الغذائية مما أدى إلي الاستخدام غير المرشد للخزانات الجوفية والتي تعد في كثير من الأحيان غير متجددة. وللوفاء بالمتطلبات الحالية والمستقبلية من الموارد المائية بدول المنطقة فإن هناك بديلان ينحصران في نقل واستيراد المياه من دول الجوار الجغرافي أو الاتجاه إلي الاستثمار في إنشاء محطات التحلية. وقد تم من خلال هذا البحث الدراسة المستفيضة لخيارات و بدائل نقل واستيراد المياه من دول الجوار الجغرافي وتكلفة كل بديل وكمية المياه التي يمكن نقلها. كما تمت دراسة البدائل المطروحة لتحلية المياه وتكلفة إنتاج المياه من التحلية في ضوء التطور التقني واستخدام الأغشية ودمج إنتاج المياه والكهرباء لتقليل التكلفة. كما تم كذلك دراسة تأثير ارتفاع سعر النفط على إنتاج المياه من محطات التحلية والآثار البيئية للمحطات ومدى استدامة مصادر التحلية في المنطقة على المدى الطويل. ثم تم مناقشة وتحليل كل من الخيارين الاستراتيجيين من وجه النظر الفنية والاقتصادية والبيئية والسياسية وكذلك تأثير كل منها على التنمية المستدامة قصيرة الأمد وطويلة الأمد في دول المنطقة. وقد دلت نتائج البحث على أن التحلية هي الخيار الإستراتيجي الأفضل في الوقت الراهن بالمقارنة مع خيار نقل المياه من دول الجوار الجغرافي من حيث التكلفة وتأثيره على القطاعات التنموية على المدى الطويل وذلك بالرغم من حساسية محطات التحلية لعناصر التلوث أو بعض المخاطر الأخرى. غير أن ذلك يمكن التغلب عليه ببناء شبكة من محطات التحلية وربطها للتغلب على مثل تلك الطوارئ الأمر الذي قد يتطلب ذلك كثير من الاستثمارات المالية.